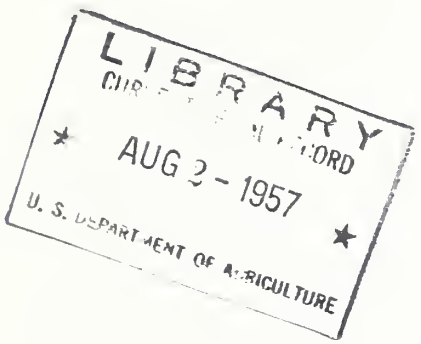
STORAGE STUDIES ON MARSH GRAPEFRUIT--1955-56 SEASON:

I EFFECT OF NITROGEN AND POTASH FERTILIZATION ON KEEPING QUALITY

II EFFECT OF DIFFERENT TEMPERATURE COMBINATIONS ON KEEPING QUALITY



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by

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SUMMARY

Two series of storage tests with Marsh grapefruit grown on rough lemon rootstock were conducted at Orlando, Fla., during the 1955-56 season. One series consisted of three tests to determine the effect of fertilizing the soil with nitrogen and potash on keeping quality of grapefruit. The fruits tested were from plots given high, medium, and low levels of nitrogen and potash. The other series consisted of four tests to determine the effect of different temperature combinations on keeping quality of grapefruit obtained from commercial packinghouses.

Maturity of the fruit as well as conditions during storage and the subsequent holding period seemed to have more influence on the incidence of pitting and decay than nitrogen or potash fertilization of the trees. Very little pitting or decay was found in fruit stored 8 weeks at 50° F. Virtually all of the fruit stored 8 weeks at 40° was pitted and the remainder was decayed. Injured fruit soon developed decay during the holding period. Pitting increased rapidly during the 7-day holding period at 70° on fruit previously stored 8 weeks at 32°. Decay appeared between the third and seventh day at 70° and was much higher in the 8-week test than in the 6-week test. No pitting was found and decay developed very slowly in fruit stored 1 week at 50° and held 28 days at 70°. There was no consistent relation between levels of nitrogen and potash fertilization and pitting and decay.

Pitting in grapefruit obtained from commercial packinghouses did not become prevalent until the last 2 tests. These fruits were stored April 25 and May 8, 1956, respectively. Rind breakdown frequently was lower in fruit stored at 40° F., with or without previous storage at 50°, than in fruit stored at 32°. While it did not appear to affect the amount of pitting, storage of the fruit at 50° for 1 or 2 weeks before transferring it to 32° eliminated most of the surface browning so often found in fruit stored continuously at 32° and also prevented the appearance of the objectionable deep yellow color found in fruit stored continuously at 50°.

In all 4 tests, decay in fruit stored continuously at 32°, 40°, and 50° F. (the so-called standard treatments) followed the same general pattern noted in previous years. Fruit stored at 50° nearly always developed considerable decay during storage. Those at 32° or 40° showed a more rapid appearance of decay during the holding period, especially between the third and seventh day. Less decay developed during the holding period when the fruit was stored 1 or 2 weeks at 50° before it was transferred to 32°. In most cases the shorter period at 50° gave better results. Some reduction in decay was also obtained when the lower temperature was 40°. Storage first at 32° and then at 50° was not successful as the amount of decay was higher than at continuous storage at 50°.

REVIEW OF LITERATURE

In previous years considerable study has been made on the storage of grapefruit. The major effort in most instances has been focused on the determination of (a) optimum storage conditions and (b) packinghouse methods and treatments for the control of decay.

As far back as 1920 Hawkins and Magness (5)[1] pointed out that an undesirable feature of cold storage was the breaking down or pitting of the peel at temperatures of 40° F. or lower. The authors described pitting and stated that this breaking down on the peel begins as a slightly sunken spot, which increases in size and becomes brown in color. The sunken portions are usually not more than one-half inch in diameter, but several may

[1] Underscored figures in parentheses refer to Literature Cited, page 8.

coalesce, making a large sunken area of dark-brown tissue. This does not extend into the pulp, and the flavor is apparently unaffected, but the fruit is rendered unsightly. Hawkins and Magness (5) stated that the best storage temperature seemed to be 32°, for at this temperature pitting was less marked. They pointed out that pitting of grapefruit does not apparently develop at high temperatures but occurs only on the cold-storage fruit.

In a rather comprehensive series of tests Brooks and McColloch (1) found that pitting was more prevalent in small lots of Florida grapefruit stored at 36° or 40° than 30°, 32°, 50°, or 60° F. Fruit stored at 30° or 32° for periods of 5 to 13 weeks had a form of mild pitting while that at 50° or 60° F. had little or no pitting. On removal to 70° F. fruit previously stored at 32° F. showed a greater increase in pitting than fruit from 36° F. They found a definite reduction in pitting when fruit was held for 4 to 10 days at 50° or 60° F. or for 8 to 24 hours at 100 to 110° F. before storage at 36°. The incidence of pitting was reduced when fruit was removed from 32° or 36° F. to 70° F. (65° to 75° F.) or 60° F. for 1 day at the end of 1 week and again for 1 day at the end of 2 weeks. There was no reduction if the change was made after the fruit had been in storage at 32° or 36° F. for 3 weeks or more. Pitting was also partially inhibited when fruit was removed permanently from 32° or 36° to 50° F. at the end of 1, 2, or 3 weeks. Attempts to isolate possible causal organisms of pitting were made. Chiefly bacteria were found, at least one culture of which induced pitting when a dilute suspension was injected just under the rind of sound fruit. Brooks and McColloch also induced pitting by subjecting fruit to vapors of various chemicals. Extracts of peel oil from lemons and grapefruit when placed on the rind induced pitting in some instances, but more often resulted in oleocellosis. Pre-storage treatments with air mixtures of 25 to 45 percent carbon dioxide were helpful towards reducing pitting in fruit stored at 36° or 40° F.

Friend and Bach (2) working with Texas fruit reported that a temperature of 45° F. was more satisfactory for the storage of grapefruit than the lower temperatures. In this connection they stated that 31° to 32° retarded the development of decay in the stored fruit but increased the losses due to pitting and scald.

Stahl and Camp (8) stated that the best temperatures for the storage of Florida Silver Cluster and Marsh Seedless grapefruit were from 37.5° to 42° F., preferably 37.5°.

Ryall and Buford (7) reported that 46° to 50° F. was better than 32° to 34° or 38° to 40° for the storage of Texas grapefruit. Storage pitting was worse on grapefruit at 38° to 40°.

Johnson, Buford, and Ryall (6) reported successful storage of Marsh grapefruit for 8, 12, and 14 weeks in Texas. Their best results were obtained from storage at 52° F. in that pitting and surface browning were of minor importance and less Penicillium decay developed during the post-storage holding period.

Wiant, et al. (9) conducted storage investigations in 1951 on Florida Marsh and Duncan grapefruit at Orlando, Fla., and at New York, N. Y. They reported that storage for 8 weeks was completely unsuccessful because of the serious amount of pitting at 32° and 38° F. and the prevalence of decay at all temperatures (32°, 38°, 45°, 50°, and 55°). The results showed that decay developed rapidly during the holding period at 70° following storage. Also, they reported that where pitting occurred it was worse at 38° than at lower or higher temperatures.

Harding et al. (3, 4) reported storage studies on Florida grapefruit. Decay was not significantly reduced as a result of "curing" (60 hours at 84° F.) or packaging with phenodor-treated box liners. It was concluded that grapefruit can be successfully held at 32° for about 4 weeks. Some control of decay resulted from pre-storage treatments with Dowicide A (sodium orthophenylphenate) - hexamine (hexamethylene-tetramine) and 2-amino-pyridine-pyrrolidine, but control was not sufficient to permit storage much longer than 4 weeks. The borax treatment (immersing the fruit for 10 seconds in a 5-percent solution of borax) weakened the fruit and made it susceptible to pitting and decay.

Harding et al. (4) determined the keeping quality of Florida grapefruit stored at 32° F. in polyethylene bags and lined boxes. They reported that carbon dioxide and oxygen atmospheres within the bags were partly controlled by breaking the seals on the bags at definite times. Some treatments showed promise for short storage periods, but 9 weeks at 32° proved too long, because high percentages of decay developed after removal from cold storage. Fruit stored in polyethylene bags was usually soft. If the seals were not broken on the polyethylene bags off-flavors developed in the fruit.

MATERIALS AND METHODS

Storage studies on Marsh grapefruit were conducted during the 1955-56 season at Orlando, Fla. Fruit from trees on rough lemon rootstock in groves located in Lake and Pinellas Counties was used. Two series of tests were conducted, one with grapefruit from soil fertilization plots[2] to determine the effect of nitrogen and potash fertilization on keeping quality, and the other with grapefruit from commercial packinghouses to determine the effect of different temperatures on pitting, decay, and storage quality.

The fertilization plots, which were in a grove near Groveland in Lake County, included replicated treatments of high, medium, and low levels of nitrogen and of potash.

Test 1. Fruit was picked from several trees in each of the plots having fertilization treatment on November 21, 1955. It was packed in Bruce boxes as size 80 (70-96) without washing or other treatment, and stored on November 22. Each subsample consisted of 3 boxes. The fruit was stored at 32°, 40°, and 50° F. for 8 weeks. Market life of the fruit after storage was determined by a holding period of 7 days at 70°.

Inspection of fruit was similar to that in former storage studies (3, 4, 9). Inspections were made at the time the boxes were removed from storage and after 3 and 7 days at 70° F. The fruit was scored for slight and severe aging, slight, moderate, and severe pitting, stem-end rot, Penicillium rot, and miscellaneous decay. Data for severe aging and moderate and severe pitting, the rind breakdowns considered of commercial importance, are combined into a single group, pitting, for purposes of this report. Records for pitting at the second and third inspections are based on counts made at the particular inspection and are not cumulative. Decayed grapefruit at the first and second inspections were discarded and the sound fruit repacked, hence the data for decay are cumulative.

A composite sample (25 fruit) from each fertilization treatment was analyzed before storage for weight of fruit that was juice, total soluble solids, total acid, solids-to-acid ratio, and ascorbic acid (milligrams per milliliter). Similar analyses were made on the treatments from each of the storage temperatures at the end of the holding period. Flavor of fruit in the high, medium, and low levels of nitrogen and potash was rated by a taste panel.

Test 2. A second picking from the fertilization plots was made February 14, 1956. The fruit was packed in Bruce boxes as size 64 without washing or other treatment and stored February 15. The storage temperature was 32° F. and the storage period was 6 weeks. Each subsample consisted of 6 boxes. Inspections were made and data recorded as in the previous test. Rind color was observed at each inspection. Analyses were made for total soluble solids, total acid, and solids-to-acid ratio at the end of the holding period. Flavor of fruit was rated by a taste panel.

Test 3. Additional boxes of grapefruit from each fertilization treatment were picked on February 14. Unwashed fruit was packed in Bruce boxes as size 64 and stored February 15. The fruit was stored at 50° F. for 1 week. Market life of the fruit after storage, which simulated transit to a northern market, was determined by a holding period of 28 days at 70°. The fruit was inspected when the boxes were removed from 50° and after 3,

[2] Acknowledgment is made to Dr. Paul F. Smith of the Subtropical Fruit Investigations Section, Agricultural Research Service, Orlando, Fla., who had general supervision of the soil fertilization grapefruit plots.

7, 14, 21, and 28 days' holding. Data were recorded as in the previous test except that no analyses or flavor ratings were made.

To determine the effect of time and temperature on keeping quality Marsh grapefruit used in tests was obtained from commercial packinghouses in Lake and Pinellas Counties. The commercial packinghouse treatments consisted of washing, waxing, polishing, grading, sizing, and packing. Fruit of size 72 and grade U. S. 1 was packed in 4/5-bushel plain telescope cartons in one test, and in 1-3/5-bushel Bruce boxes in the other three. Each subsample consisted of 10 cartons or 6 boxes. These tests were as follows:

Test 4. Eight weeks' storage test with Lake County fruit in cartons: Picked February 6, 1956, and packed and stored February 8. Fifteen treatments: 32° F. for 8 weeks; 32° for 1, 2, 3, and 4 weeks, then 50° for 7, 6, 5, and 4 weeks, respectively; 50° for 8 weeks; 50° for 1, 2, 3, and 4 weeks, then 40° for 7, 6, 5, and 4 weeks; 50° for 8 weeks; and 50° for 1, 2, 3, and 4 weeks, then 32° for 7, 6, 5, and 4 weeks.

Test 5. Six weeks' storage test with Lake County fruit: Picked April 9, 1956, packed April 10, and stored April 12. Seven treatments: 32°, 40°, and 50° F. for 6 weeks; 50° for 1 and 2 weeks, then 32° for 5 and 4 weeks, respectively; and 50° for 1 and 2 weeks, then 40° for 5 and 4 weeks.

Test 6. Six weeks' storage test with Pinellas County fruit: Picked April 24, 1956, packed and stored April 25. Seven treatments as in test 5.

Test 7. Four, 6, and 8 weeks' storage test with Lake County fruit: Picked May 8, 1956, packed May 9, and stored May 10. Fifteen treatments: 32°, 40°, 50° F. for 4, 6, and 8 weeks; 50° for 1 week, then 32° for 3, 5, and 7 weeks; and 50° for 1 week, then 40° for 3, 5, and 7 weeks.

Inspections were made at the time the cartons or boxes were removed from storage and after 3 and 7 days at 70° F. Data on pitting, decay, and rind color were recorded as in the previous tests. Total soluble solids, total acid, and solids-to-acid ratio were determined on composite samples (15 fruit) for 5 of the treatments in test 4 at the end of the holding period. These constituents, weight of fruit that was juice, and acidity (pH) were determined on composite samples (25 fruit) for all of the treatments in tests 5, 6, and 7 before storage and at the end of the holding period. Flavor of the fruit was judged by an informal taste panel.

RESULTS AND DISCUSSION

I Effect of Nitrogen and Potash Fertilization on Keeping Quality

Test 1. Marsh grapefruit picked from plots given high, medium, and low levels of nitrogen and potash fertilization showed very little pitting after 8 weeks' storage at 32° or 50° F. (table 1). Virtually all of the fruit stored at 40° was pitted upon removal. Pitting increased appreciably in the 32° lots and very little in the 50° lots during the holding period at 70°. Many of the injured fruit of the 40° lots quickly succumbed to decay so that the apparent amount of pitting decreased. These results were similar to those reported in previous storage tests (1, 3, 4, 7, 9). Trends among the different levels of nitrogen and potash were not consistent from one storage temperature to another. The amount of pitting decreased with increased level of nitrogen at 32° and 50° but showed an opposite trend at 40°. At 32° less pitting was found in medium potash fruit than the high or low levels and at 50°, the reverse was true.

No decay was found in lots stored 8 weeks at 32° F., and very little at 50° upon removal of the fruit from storage. Decay appeared in the 32° lots between the third and seventh day of the holding period and ranged from 18 to 40 percent at the end of the holding period. Only 0 to 3 percent decay was found in the 50° lots at the final inspection. More decay was recorded in the 40° lots than the others at the time of removal from

storage and it increased rapidly during the holding period. In general, fruit in the 3 nitrogen lots showed somewhat less decay than the potash.

Fruit from the low potash plots contained somewhat more juice and generally lower total soluble solids, total acid, and ascorbic acid than those from the other plots (table 2). Differences among the fruit and changes during storage and the holding period were small. All of the lots decreased somewhat in solids and usually in acid but increased in weight of fruit that was juice. Fruit of the high, medium, and low levels of nitrogen and potash were all pleasantly tart to sweet in flavor.

Test 2. No pitting or decay was found in grapefruit stored 6 weeks at 32° when the fruit was removed from storage (table 3). Contrary to the previous test, little pitting developed during the holding period. Decay appeared between the third and seventh day of holding at 70° but was much lower in all lots than in the 8 weeks' test. Fruit showing less pitting also had less decay. Except for the medium potash fruit the nitrogen lots had less decay than the potash.

Total soluble solids, total acid, and solids-to-acid ratio (table 4) tended to be lower than in the previous test. All of the fruit was pleasantly tart to sweet in flavor. Fruit in the potash lots were noticeably greener in rind color but all tended to develop yellow rind color during storage and the holding period.

Test 3. Grapefruit stored for 1 week at 50° and held for 28 days at 70° showed no sign of pitting (table 5). Decay developed very slowly during the holding period. Unlike the storage tests more decay appeared in the nitrogen lots than in the potash. After 28 days at 70° F. the medium level of potash showed the least decay, 3 percent, and the high level of nitrogen the most, 11 percent. The rind color of the potash fruit was somewhat greener than the nitrogen at the beginning of the storage period but this difference gradually disappeared during the holding period. All of the fruit was pleasantly tart to sweet in flavor. The lowest rating, 81, was given to the low potash fruit which were smaller than the general average, and the highest, 85, to fruit in each of the 3 levels of nitrogen.

The foregoing results indicate that fertilization with high, medium, and low levels of nitrogen or potash has less influence on the incidence of pitting and decay than maturity of the fruit and conditions during the storage and marketing periods.

II Effect of Different Temperature Combinations on Keeping Quality

Test 4. Thirteen of the 15 treatments showed no pitting whatever after 8 weeks' storage and 7 days at 70° F. (table 6). A treatment with fruit stored 8 weeks at 40° was not included in the test but very little pitting (or severe aging) appeared in fruit stored 1 to 4 weeks at 50°, then 40° for 7 to 4 weeks. So little pitting was found that no conclusions could be drawn as to the influence of the different treatments upon rind breakdown.

As expected from results of previous storage tests (3, 4, 7, 9), the highest percentages of decay when the boxes were removed from storage were in treatments where the fruit was stored 4 to 8 weeks at 50° F. Storage for 1 to 4 weeks at 32° before transferring the fruit to 50° resulted in little or no decrease in decay. Storage for 1 to 3 weeks at 50°, however, reduced decay markedly and the effect was greater where the second temperature was 32° instead of 40°. Fruit stored 8 weeks at 32° had 32 percent decay at the end of the holding period while that stored 1 week at 50° then 32° for 7 weeks had only 9 percent. Storage for 2 or 3 weeks at 50° then 6 or 5 weeks at 32° or 1 to 3 weeks at 50° then 7 to 5 weeks at 40° gave somewhat more decay at the end of the holding period but the percentages were still lower than the 32° or 50° controls. Fruit stored 4 weeks at 50° then 4 weeks at either 40° or 32° had the same or somewhat less decay than the 50° control.

Total soluble solids, total acid, and solids-to-acid ratio were comparable in the 5 treatments which were analyzed (table 7). Changes in rind color were slight except in the case of fruit stored for the longer periods at 50°. The latter were deep yellow when they were removed from storage. Most of the other treatments had approximately the same light yellow or light greenish yellow color which they had when stored. All of the fruit deepened in yellow color during the holding period and this was most noticeable in fruit stored at 50° for 3 to 8 weeks. No storage or other "off taste" was detectable in the fruit when tasted at the conclusion of the test.

Numerous experiments with curing of fruit at high temperatures have been reported in the literature. Curing of oranges and grapefruit was often recommended as a commercial practice and short curing periods such as would be obtained in the degreening process are still considered beneficial towards suppression of certain types of decay, notably Penicillium rots. The results obtained in the present test corroborate those of Brooks and McColloch (1) with regard to the possible curing effect of a regular storage temperature. The Marsh grapefruit used in the present test were picked early in their season of maturity, February 6, and as shown by the very small amount of pitting had good vitality. The fruit was stored 8 weeks, a much longer period than normally considered safe or feasible for Florida grapefruit; yet a curing effect was plainly evident in fruit stored for 1 week at 50° F. before transfer to a lower temperature. Not only was the percentage of decay upon removal of the boxes from storage equal to or only slightly higher than that in fruit stored continuously at 32° but decay was less at the end of the holding period. Another beneficial effect of the short storage at 50° was in reduction of surface browning which is typically prevalent on fruit stored long periods at 32°.

Test 5. Little pitting developed in Marsh grapefruit during 6 weeks of storage or the subsequent holding period although 1 to 4 percent severe aging was found (table 8). Decay upon removal of the boxes from storage ranged from none in the continuous 32° F. storage to 22 percent in the continuous 50°. That for 1 week at 50° then 5 weeks at either 32° or 40° resulted in a considerable reduction of decay compared to continuous 50°. Storage for 6 weeks at 40° also gave a low percentage of decay. At the end of the holding period the results were quite different. Fruit stored 6 weeks at 32° had 77 percent decay and that in the other treatments ranged from 36 to 48 percent decay.

Total soluble solids increased 0.4 to 1.1 percent and total acid decreased 0.07 to 0.24 percent during storage (table 9). Fruit stored at 50° for 6 weeks were a little deeper in color than those in other treatments and all of them tended to darken in shade during the holding period. Flavor of the fruit was acceptable in all treatments.

Test 6. Three percent pitting was found in fruit stored 6 weeks at 32° and none in other treatments when the boxes were removed from storage (table 8). Pitting developed rapidly in some lots between the first and second inspections and decreased between the second and third inspections as injured fruit succumbed to decay. More pitting was found in the Pinellas County fruit than in Lake County fruit. No severe aging was recorded.

The percentage of decay was generally lower in the Pinellas County fruit than in the Lake County fruit. Unlike results noted in the 8-week test, fruit stored 2 weeks at 50° then 4 weeks at 32° had less decay at the end of the holding period than other treatments. Fruit stored 6 weeks at 40°, 1 week at 50°, then 5 weeks at either 32° or 40°, and 2 weeks at 50° then 4 weeks at 40° all had approximately the same amounts of decay. While too high to be of much practical value, decay in these treatments was 8 to 10 percent lower than continuous 50° and very much lower than continuous 32°.

Value for weight of fruit that was juice, total soluble solids, total acid, and acidity (pH) before storage and after the holding period are given in table 9. Rind color and flavor of the fruit were similar to those of test 5.

The results of the two 6-week storage tests indicate that the curing effect of a short storage period at 50° is most prominent in fruit less prone to decay. Pitting was unusually low in the 40° treatments as tests in previous years (3, 4, 7, 9) have generally

shown more rind breakdown at this temperature than either 32° or 50°. Less pitting was usually found in fruit with less decay.

Test 7. Little pitting was found when the fruit was removed from storage (table 10). Fruit stored for 8 weeks at 32° showed 4 percent pitting while that stored 1 week at 50° then 7 weeks at 40° had 3 percent severe aging. Pitting developed rapidly during the holding period. Many of the injured fruit decayed so that the amount of rind breakdown was smaller at the third inspection. Severe aging was found in many of the 6- and 8-week treatments.

Fruit stored at 50° for 4, 6, or 8 weeks had 17, 27, and 33 percent decay, respectively, on removal of the boxes from storage. By contrast, fruit stored 1 week at 50° then 3, 5, or 7 weeks at 32° had 1, 1, and 2 percent decay, respectively. These same fruit had 2 to 3 percent decay after 3 days at 70°. Decay developed rapidly in all of the fruit between the third and seventh day of the holding period. Storage for 1 week at 50° before transference to 32° did, however, result in much less decay than either continuous 50° or continuous 32°.

The weight of fruit that was juice and total acid decreased during storage and the holding period (table 11). Total soluble solids increased 0.1 to 0.5 percent in fruit stored 4 and 8 weeks and decreased 0.1 to 0.2 percent in fruit stored 6 weeks. Solids-to-acid ratio increased and acidity (pH) gradually decreased during storage. Fruit stored at 50° were noticeably deeper yellow in color than the rest which were light yellow for the most part. All of the fruit darkened somewhat with increased length of storage and also during the holding period. Flavor of the fruit after 4, 6, and 8 weeks of storage was acceptable.

The findings in the 4 storage tests with Marsh grapefruit obtained from commercial packinghouses bear out in general the results reported in previous years (1, 3, 4, 7, 9) for fruit stored continuously at 32°, 40°, or 50° F. Very little pitting or other rind breakdown developed in the fruit until the last 2 tests and then it was generally most severe at 32°. Fruit picked early in the season could be stored for longer periods with less development of decay. Fruit stored at 50° nearly always had more decay than fruit stored at 40° or 32° when the boxes were removed from storage. Decay in fruit stored at 32° was usually very low but surface browning (scald) often disfigured the fruit. During the first 3 days of the holding period decay increased rather slowly but developed rapidly thereafter.

Rind breakdown did not become prevalent until the last 2 pickings and frequently was lower in fruit stored at 40° F., with or without previous storage at 50°, than in fruit stored at 32°. While it did not appear to affect the amount of rind breakdown, storage at 50° for 1 or 2 weeks before transference to 32° eliminated most of the surface browning found in fruit stored continuously at 32° and also prevented the appearance of the objectionable deep yellow color found in fruit stored continuously at 50°.

Less decay developed during the holding period when the fruit was stored for 1 or 2 weeks at 50° F. before it was transferred to 32°. In most cases, the shorter period at 50° gave better results. Some reduction in decay was also obtained when the lower temperature was 40°. Storage of fruit first at 32° then 50° was not successful as the amount of decay was higher than when held continuously at 50°.

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APPENDIX

TABLE 1.--Effect of nitrogen and potash fertilization on pitting and decay of Marsh grapefruit stored 8 weeks at 32°, 40°, and 50° plus 3 and 7 days at 70° F.[1]

Fertilizer used on plot; level at which applied	Storage temperature	Number of fruits	Fruit pitted after 8 weeks' storage + indicated period at 70° F.[2]			Fruit decayed after 8 weeks' storage + indicated period at 70° F.[3]		
			0 day	3 days	7 days	0 day	3 days	7 days
Nitrogen	*F.*		*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
High.....	32°	240	0	3	8	0	0	23
Medium.....		240	0	5	[4] 9	0	0	18
Low.....		240	0	5	17	0	0	28
Potash								
High.....		240	0	1	15	0	0	38
Medium.....		240	0	5	5	0	0	40
Low.....		240	1	3	19	0	0	32
Nitrogen								
High.....	40°	240	99	87	65	1	13	35
Medium.....		240	95	83	52	5	17	48
Low.....		240	97	80	33	3	20	67
Potash								
High.....		240	98	86	30	2	14	70
Medium.....		240	98	82	43	2	18	57
Low.....		240	98	90	64	2	10	36
Nitrogen								
High.....	50°	240	0	0	0	0	0	0
Medium.....		240	0	1	1	1	1	2
Low.....		240	1	1	2	0	0	1
Potash								
High.....		240	0	0	0	0	1	2
Medium.....		240	1	1	4	1	3	3
Low.....		240	1	1	2	1	1	3

[1] Stored November 22, 1956.
[2] Data not cumulative; includes moderate and severe pitting and severe aging.
[3] Data cumulative; includes stem-end rot, Penicillium rot and miscellaneous decay.
[4] Includes 1 percent severe aging.

TABLE.2.--Changes in percentage of juice and chemical constituents in Marsh grapefruit picked from fertilizer test plots and stored 8 weeks at 32°, 40°, and 50° plus 7-day holding period at 70° F.[1]

Fertilizer used on plot; level at which applied	Storage temperature	Weight of fruit that was juice	Total soluble solids	Total acid	Solids-to-acid ratio	Acidity	Ascorbic acid per ml.
			Before storage				
Nitrogen	*F.*	*Pct.*	*Pct.*	*Pct.*		*pH*	*Mg.*
High	(Before storage)	49	9.2	0.94	10:1	3.3	0.39
Medium		49	9.2	0.90	10:1	3.3	0.42
Low		49	9.2	0.85	11:1	3.4	0.45
Potash							
High		49	9.9	1.00	10:1	3.3	0.42
Medium		50	9.4	0.95	10:1	3.3	0.41
Low		53	9.1	0.89	10:1	3.3	0.37
			After 8 weeks' storage and 7-day holding period				
Nitrogen							
High	32°	49	8.5	0.89	10:1	3.4	0.36
Medium		51	8.0	0.80	10:1	3.5	0.39
Low		50	8.6	0.79	11:1	3.5	0.43
Potash							
High		51	8.8	0.92	10:1	3.4	0.39
Medium		50	8.4	0.87	10:1	3.3	0.40
Low		51	8.7	0.78	11:1	3.4	0.34
Nitrogen							
High	40°	52	8.6	0.94	9:1	3.4	0.38
Medium		52	8.6	0.90	10:1	3.4	0.40
Low		52	8.6	0.85	10:1	3.4	0.44
Potash							
High		52	9.0	1.00	9:1	3.4	0.42
Medium		54	8.4	0.90	9:1	3.3	0.39
Low		53	8.9	0.83	11:1	3.3	0.36
Nitrogen							
High	50°	51	8.6	0.90	10:1	3.4	0.38
Medium		53	8.6	0.87	11:1	3.4	0.41
Low		51	8.6	0.82	10:1	3.5	0.44
Potash							
High		52	8.8	0.95	9:1	3.4	0.40
Medium		51	8.4	0.88	10:1	3.4	0.39
Low		54	8.7	0.79	11:1	3.4	0.35

[1] Analyses made on composite samples of 25 fruit per treatment.

TABLE 3.--Effect of nitrogen and potash fertilization on pitting and decay of Marsh grapefruit stored 6 weeks at 32° plus 3 and 7 days at 70° F.[1]

Fertilizer used on plot; level at which applied	Number of fruits	Fruit pitted after 6 weeks' storage + indicated period at 70° F.[2]			Fruit decayed after 6 weeks' storage + indicated period at 70° F.[3]		
		0 day	3 days	7 days	0 day	3 days	7 days
Nitrogen		*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
High	384	0	1	2	0	0	8
Medium	384	0	1	1	0	0	7
Low	383	0	1	1	0	0	7
Potash							
High	384	0	3	3	0	0	14
Medium	382	0	1	[4] 2	0	0	6
Low	400	0	2	[4] 3	0	0	11

[1] Stored February 15, 1956.
[2] Data not cumulative; includes moderate and severe pitting and severe aging.
[3] Data cumulative; includes stem-end rot, Penicillium rot and miscellaneous decay.
[4] Includes 1 percent aging.

TABLE 4.--Total soluble solids, total acid, solids-to-acid ratio, and flavor rating of Marsh grapefruit from fertilizer plots and stored 6 weeks at 32° plus 7-day holding period at 70°F.[1]

Fertilizer used on plot; level at which applied	Total soluble solids	Total acid	Solids-to-acid ratio	Flavor rating[2]
Nitrogen	*Pct.*	*Pct.*		
High	8.1	0.86	9:1	80
Medium	8.1	0.85	9:1	82
Low	7.4	0.76	10:1	79
Potash				
High	7.7	0.87	9:1	79
Medium	7.8	0.79	10:1	80
Low	8.7	0.77	11:1	81

[1] Analyses made on composite samples of 25 fruit per treatment.
[2] 70-79 = pleasantly tart; 80-89 = pleasantly tart to sweet.

TABLE 5.--Effect of nitrogen and potash fertilization on pitting and decay of Marsh grapefruit stored 1 week at 50° plus 3, 7, 14, 21, and 28 days at 70° F.[1]

Fertilizer used on plot; level at which applied	Number of fruits	Fruit pitted after 1 week's storage + indicated period at 70° F.[2]						Fruit decayed after 1 week's storage + indicated period at 70° F.[3]					
		0 day	3 days	7 days	14 days	21 days	28 days	0 day	3 days	7 days	14 days	21 days	28 days
Nitrogen		*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
High	384	0	0	0	0	0	0	0	0	0	3	6	11
Medium	384	0	0	0	0	0	0	0	0	0	1	4	7
Low	384	0	0	0	0	0	0	0	0	1	3	5	8
Potash													
High	381	0	0	0	0	0	0	0	0	0	1	2	5
Medium	318	0	0	0	0	0	0	0	0	0	1	2	3
Low	399	0	0	0	0	0	0	0	0	1	2	5	7

[1] Stored February 15, 1956.
[2] Data not cumulative; includes moderate and severe pitting and severe aging.
[3] Data cumulative; includes stem-end rot, Penicillium rot and miscellaneous decay.

TABLE 6.--Effect of time and temperature on pitting and decay of Marsh grapefruit stored 8 weeks at specified temperatures plus 3 and 7 days at 70° F.[1]

Storage treatment	No. of fruits	Fruit pitted after 8 weeks' storage + indicated period at 70° F.[2]			Fruit decayed after 8 weeks' storage + indicated period at 70° F.[3]		
		0 day	3 days	7 days	0 day	3 days	7 days
32°F. for--							
8 weeks	358	0	0	0	0	0	32
1 week, then 50° for 7 weeks	356	0	0	0	15	18	24
2 weeks, then 50° for 6 weeks	356	0	0	0	15	18	26
3 weeks, then 50° for 5 weeks	360	0	0	0	12	17	26
4 weeks, then 50° for 4 weeks	352	0	0	0	10	15	23
50° F. for--							
8 weeks	360	0	0	0	14	16	21
1 week, then 40° for 7 weeks	360	0	0	0	1	3	15
2 weeks, then 40° for 6 weeks	360	0	[4] 1	[4] 1	3	4	11
3 weeks, then 40° for 5 weeks	360	0	0	0	3	6	15
4 weeks, then 40° for 4 weeks	360	0	0	1	11	12	18
50° F. for--							
8 weeks	360	0	0	1	15	18	24
1 week, then 32° for 7 weeks	360	0	0	0	0	0	9
2 weeks, then 32° for 6 weeks	356	0	0	0	2	2	11
3 weeks, then 32° for 5 weeks	360	0	0	0	1	1	15
4 weeks, then 32° for 4 weeks	360	0	0	0	7	8	21

[1] Stored February 8, 1956; 4/5-bushel plain telescoped cartons.
[2] Data not cumulative; includes moderate and severe pitting and severe aging.
[3] Data cumulative; includes stem-end rot, Penicillium rot and miscellaneous decay.
[4] Severe aging.

TABLE 7.--Total soluble solids, total acid, and solids-to-acid ratio of Marsh grapefruit stored 8 weeks at specified temperatures, plus 7 days at 70° F.[1]

Storage treatment (plus 7 days at 70° F.)	Total soluble solids	Total acid	Solids-to-acid ratio
	Pct.	*Pct.*	
32° F. for--			
8 weeks[2]	10.8	1.27	8:1
1 week, then 50° for 7 weeks	10.3	1.28	8:1
50° F. for--			
8 weeks	10.7	1.20	9:1
1 weeks then 40° for 7 weeks	10.7	1.30	8:1
1 week, then 32° for 7 weeks	10.7	1.28	8:1

[1] Analyses made on composite samples of 15 fruit per treatment.
[2] Twelve fruit.

TABLE 8.--Effect of time and temperature on pitting and decay of Marsh grapefruit stored 6 weeks at specified temperatures plus 3 and 7 days at 70° F.

Date stored and storage treatment	Number of fruits	Fruit pitted after 6 weeks' storage + indicated period at 70° F.[1]			Fruit decayed after 6 weeks' storage + indicated period at 70° F.[2]		
		0 day	3 days	7 days	0 day	3 days	7 days
April 12, 1956[3]							
50° F. for--		*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
6 weeks	428	[4] 1	[4] 1	0	22	28	44
1 week, then 32° for 5 weeks	422	0	[4] 1	0	2	4	46
2 weeks, then 32° for 4 weeks	429	0	[4] 2	[4] 1	4	7	36
40° for 6 weeks	432	0	[5] 2	[4] 2	3	11	41
50° for--							
1 week, then 40° for 5 weeks	432	[4] 3	[4] 4	[4] 3	5	12	46
2 weeks, then 40° for 4 weeks	432	[4] 2	[4] 2	[4] 1	7	16	48
32° for 6 weeks	435	0	2	2	0	3	77
April 25, 1956[6]							
50° F. for--							
6 weeks	429	0	0	0	8	16	27
1 week, then 32° for 5 weeks	428	0	5	4	1	1	17
2 weeks, then 32° for 4 weeks	427	0	0	0	1	1	12
40° for 6 weeks	431	0	2	1	1	3	19
50° for--							
1 week, then 40° for 5 weeks	430	0	1	1	1	3	18
2 weeks, then 40° for 4 weeks	427	0	1	1	1	3	17
32° for 6 weeks	432	3	11	6	0	1	52

[1] Data not cumulative; includes moderate and severe pitting and severe aging.
[2] Data cumulative; includes stem-end rot, Penicillium rot and miscellaneous decay.
[3] Packinghouse A, Lake County.
[4] Severe aging.
[5] Includes 1 percent severe aging.
[6] Packinghouse B, Pinellas County.

TABLE 9.--Changes in percentage of juice and chemical constituents of Marsh grapefruit stored 6 weeks at specified temperatures plus 7-day holding period at 70° F.[1]

Date stored and storage treatment	Weight of fruit that was juice	Total soluble solids	Total acid	Solids-to-acid ratio	Acidity
April 12, 1956[2]	*Pct.*	*Pct.*	*Pct.*		*pH*
Before storage	-	10.1	1.10	9:1	-
50° F. for--					
6 weeks	-	10.4	1.03	10:1	-
1 week, then 32° for 5 weeks	-	10.5	0.86	12:1	-
2 weeks, then 32° for 4 weeks	-	10.5	0.93	11:1	-
40° for 6 weeks	-	10.4	0.95	11:1	-
50° for--					
1 week, then 40° for 5 weeks	-	10.5	0.96	11:1	-
2 weeks, then 40° for 4 weeks	-	10.5	0.91	12:1	-
32° for 6 weeks	-	11.1	0.97	11:1	-
April 25, 1956[3]					
Before storage	46	10.0	1.13	9:1	3.4
50° F. for--					
6 weeks	50	10.3	0.96	11:1	3.5
1 week, then 32° for 5 weeks	46	10.2	0.87	12:1	3.6
2 weeks, then 32° for 4 weeks	47	10.1	0.91	11:1	3.5
40° for 6 weeks	47	10.3	0.97	11:1	3.5
50° for--					
1 week, then 40° for 5 weeks	48	10.0	0.96	10:1	3.5
2 weeks, then 40° for 4 weeks	46	10.2	0.97	11:1	3.5
32° for 6 weeks	48	10.2	0.95	11:1	3.5

[1] Analyses made on composite samples of 25 fruit per treatment.
[2] Packinghouse A, Lake County.
[3] Packinghouse B, Pinellas County.

TABLE 10.--Effect of time and temperature on pitting and decay of Marsh grapefruit stored 4, 6, and 8 weeks at specified temperatures plus 3 and 7 days at 70° F.[1]

Storage treatment	Number of fruits	Fruit pitted after storage + indicated period at 70° F.[2]			Fruit decayed after storage + indicated period at 70° F.[3]		
		0 day	3 days	7 days	0 day	3 days	7 days
		Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
50° F. for--							
4 weeks	429	[4] 2	1	1	17	23	37
1 week, then 32° for 3 weeks	429	2	2	2	1	3	20
40° for 4 weeks	429	0	1	1	2	7	26
50° for--							
1 week, then 40° for 3 weeks	431	0	1	1	2	7	26
32° for 4 weeks	429	0	2	[4] 1	1	1	38
50° F. for--							
6 weeks	432	[5] 2	1	[5] 1	27	36	51
1 week, then 32° for 5 weeks	432	1	6	[4] 5	1	2	25
40° for 6 weeks	432	1	1	1	2	7	40
50° for 1 week, then 40° for 5 weeks.	431	[5] 1	[4] 2	[4] 3	3	8	30
32° for 6 weeks	428	1	8	1	2	3	41
50° F. for--							
8 weeks	432	0	0	0	33	42	58
1 week, then 32° for 7 weeks	432	2	[4] 9	[4] 3	2	2	48
40° for 8 weeks	430	1	[4] 3	[4] 2	3	10	50
50° for 1 week, then 40° for 7 weeks.	430	[6] 4	[4] 2	1	6	16	48
32° for 8 weeks	428	4	13	1	1	15	85

[1] Stored May 10, 1956.
[2] Data not cumulative; includes moderate and severe pitting and severe aging.
[3] Data cumulative; includes stem-end rot, Penicillium rot, and miscellaneous decay.
[4] Includes 1 percent severe aging.
[5] Severe aging.
[6] Includes 3 percent severe aging.

TABLE 11.--Changes in percentage of juice and chemical constituents of Marsh grapefruit stored 4, 6, and 8 weeks at specified temperatures plus 7-day holding period at 70° F.[1]

Storage treatment	Weight of fruit that was juice	Total soluble solids	Total acid	Solids-to-acid ratio	Acidity
	Pct.	*Pct.*	*Pct.*		*pH*
Before storage	46	11.4	1.07	11:1	3.6
50° F. for--					
4 weeks	43	11.7	0.94	12:1	3.6
1 week, then 32° for 3 weeks	43	11.6	0.81	14:1	3.7
40° for 4 weeks	44	11.6	0.84	14:1	3.7
50° for 1 week, then 40° for 3 weeks	43	11.9	0.86	14:1	3.7
32° for 4 weeks	44	11.6	0.87	13:1	3.6
50° F. for--					
6 weeks	41	11.2	0.81	14:1	3.7
1 week, then 32° for 5 weeks	42	11.2	0.75	15:1	3.7
40° F. for 6 weeks	44	11.2	0.81	14:1	3.7
50° for 1 week, then 40° for 5 weeks	44	11.2	0.81	14:1	3.7
32° for 6 weeks	41	11.3	0.81	14:1	3.7
50° F. for--					
8 weeks	41	11.9	0.80	15:1	3.7
1 week, then 32° for 7 weeks	43	11.5	0.78	15:1	3.8
40° for 8 weeks	44	11.5	0.78	15:1	3.8
50° for 1 week, then 40° for 7 weeks	42	11.5	0.82	14:1	3.8
32° for 8 weeks	42	11.6	0.79	15:1	3.7

[1] Analyses made on composite samples of 25 fruit per treatment.